The Role of Passengers' Satisfaction with Transit Service Quality - Dissecting Customer Satisfaction

Research thesis

Presented in partial fulfillment of the requirements for graduation with research distinction in the undergraduate colleges of The Ohio State University

By

Mingfeng Li

The Ohio State University

May 2018

Project Advisor: Dr. Andre Carrel, Department of Civil, Environmental, and Geodetic Engineering and Knowlton School of Architecture, City and Regional Planning Section

Abstract

Many large US transit agencies see high levels of ridership turnover, but currently, little is known about how turnover can be predicted. In an effort to better understand customers, many transit agencies conduct surveys at regular intervals, and a key element of those surveys are questions regarding satisfaction. This thesis dissects the relationship between satisfaction with public transportation services and passengers future travel behavior. The goal of this thesis is to show how satisfaction with transit services influences transit customer loyalty. Specifically, it is composed of three parts: First, it assesses the potential association between transit user behavior and satisfaction ratings using Chi-Square Tests. Second, using an exploratory factor analysis, it presents a model to summarize a variety of satisfaction variables with a smaller number of underlying, latent factors. Third, it analyzes the predictive power of satisfaction regarding future behavior through a structural equation model. The public transportation system that this work focuses on is the San Francisco Municipal Transportation Agency, or "Muni" for short. By analyzing survey data collected at multiple points in time, several notable findings are made, including that low satisfaction ratings with respect to service reliability appear to be associated with a decrease in transit use. It is also shown that the set of satisfaction variables presented in the survey can be summarized by four latent variables – satisfaction with reliability, the travel environment, comfort, and the schedule, respectively. Furthermore, the results suggest that the link between overall satisfaction and future changes in behavior is more complex than anticipated.

Contents

1 Introduction

Public transportation agencies and operators widely use passenger satisfaction as a key performance indicator to understand the passengers perspective and public perceptions of service quality. Customer satisfaction can also be considered as a means of gaging customer loyalty and future choice behavior [Olsen, 2007, Oliver, 2010].

In this thesis, we investigate shifts in customer satisfaction as they relate to future travel behavior. We explore the correlation among 13 satisfaction measures and estimate a structural equation model to evaluate the effects of select satisfaction measures and attitudes on future transit use intentions and, subsequently, observed behavior. This work is based on data from the San Francisco Travel Quality Study (SFTQS), which was conducted in autumn 2013 with the goal of understanding the driving factors behind transit ridership turnover. A follow-up survey, which was conducted in February 2015, is also part of this data set.

The structure of this paper is as follows. The literature review is featured in section 2, followed by a discussion of the data source and the variables in section 3. Section 4 presents the analysis of shifts in satisfaction and relates them to different behavioral groups. Section 5 offers a detailed description of the modeling framework and of the estimation results. Section 6 then summarizes the main findings and discusses the limitation of this work.

2 Literature

There is a growing body of research on traveler satisfaction. While many researchers have focused on satisfaction at a specific point in time, others have evaluated factors leading to satisfaction change. It is known that satisfaction ratings can vary at different points in time [Abou-Zeid et al., 2012]. The link between personal experiences while traveling and satisfaction is discussed by Edvardsson [1998] and Friman et al. [2001], who conducted research on negative customer responses. The former paper observed that particularly memorable, negative events relating to service reliability happened repeatedly and showed that negative events were connected to satisfaction. In the latter paper, an empirical model is presented indicating negative correlation between attribute-specific satisfaction variables and negative transit service experience. Cats et al. [2015] conducted research on the factors that influence the dynamic of customer satisfaction in Sweden and identified the following factors as being the main drivers of satisfaction: The quality of customer interface and the duration of travel time. Service reliability has been shown to have a high impact on satisfaction in several research studies [van Lierop et al., 2018, Friman et al., 2001, Edvardsson, 1998], and in addition, it has been shown that public transportation passengers explicitly take reliability into consideration when planning trips [Carrel et al., 2013]. However, each service attribute is valued differently, and one study by dellOlio et al. [2011] revealed that the qualities that passengers desire in a transit system also vary between passenger groups.

It is of particular interest to transit agencies and Metropolitan Plan-

ning Organizations to identify measures which allow them to predict transit riders future mode choice behavior. As seen in Cronin et al. [2000] and Petrick [2004], satisfaction with service quality is directly correlated with customer intentions regarding future mode choice behavior. These studies used structural equations modeling assessing the effects of satisfaction, perceived values and service quality. A similar model built by researchers studying transit riders in Taipei also takes the attractiveness of alternative transport modes into consideration [Jen and Hu, 2003]. Aside from the attributes of the transit system and the competing modes of transportation, related studies in psychology have shown that the accessibility of product attitude is an important factor that influences choice behavior [Kokkinaki and Lunt, 1997]. An important study on transit passenger satisfaction was by Eboli and Mazzulla [2007]. They investigated the bus service usage in Italy and used a structural equation model to model the interactions between overall customer satisfaction and service quality attributes. The structural equation modeling approach was also adopted by two further studies [Lai and Chen, 2011, Chen, 2008] on customer satisfaction with transit services. The structural equation models estimated in both studies showed a significant relationship between satisfaction and passengers intentions for using public transportation in the future. To the best knowledge of the author, research has so far generally focused on the link between satisfaction and behavioral intentions, but due to a lack of revealed preference data, satisfaction has rarely been connected to observed mode choice outcomes. Considering the dynamics of transit use, one can divide the population of transit users into subgroups according to how their transit use changes over time. It is

currently unknown whether satisfaction significantly differs between these behavioral groups. The first part of this thesis analyzed the dynamic of satisfaction data to validate the assumption above. Expanding on the initial work presented in this literature review, an analysis of the correlation between satisfaction variables and observed transit traveler behavior will be presented in the second part of this thesis.

3 Data Source

3.1 The San Francisco Travel Quality Study

The data were collected during the San Francisco Travel Quality Study, a large-scale study of transit traveler behavior which was conducted from October to December 2013. The design and structure of this study are explained in detail in [Carrel et al., 2017], but a brief summary is provided in the following section. The study was focused on transit passengers who used the San Francisco Municipal Transportation Agency (SFMTA), commonly referred to as Muni. One of the goals of this study was to understand whether satisfaction is correlated with behavioral intentions and whether it is a reliable predictor of passengers future travel behavior.

At the beginning of the study, participants filled out an online entry survey. Following the entry survey, they downloaded a survey app on their mobile phone. Using the survey app, they were then asked to respond to a mobile satisfaction survey on at least five days during which they had used Muni during the study period. At the end of the study, the participants filled out an online exit survey. In both the entry and exit survey, a question on

overall satisfaction with Muni was asked. Satisfaction was measured on a 5-point Likert scale, labeled very dissatisfied, dissatisfied, neutral, satisfied, and very satisfied. Following the overall satisfaction question, a list of 15 aspects of Muni service was presented, and respondents were asked to rate their satisfaction with those aspects. Responses to these questions were on the same 5-point Likert scale as the overall satisfaction question. Table 1 shows all 15 aspects of Muni service that were included; in the table, an x indicates which aspects were included in surveys.

As six weeks were not long enough to directly observe changes in transit passenger behavior, the entry and exit survey included a set of questions requesting participants to indicate their intentions and preferences regarding their future use of Muni. The design of the questions was based on two behavior change frameworks from psychology: The Theory of Planned Behavior (TPB) and the Model of Goal-Directed Behavior (MGB). The TPB suggests that an intention to change behavior is developed before any actual behavior change takes place. The MGB extends this framework to theorize that, before an intention to change behavior, a desire to change behavior is developed. The following two questions were presented in both the entry and the exit survey to capture short-term and long-term behavioral intentions:

1. In 2014, do you intend to use [Muni] more or less than you do now, or the same way as you do now?

2. How will your Muni use in January 2014 compare to your Muni use during and before the study?

The responses to each question were on a 6-point Likert scale, consisting of

"start using","Do not start using", "stop using", "use less", "use about the same" and "use more".

Table 1: Aspects of Muni service

Factor	**Entry**	**Exit**	**Follow-up**
Ability to use Muni to meet most of your travel needs	x	x	x
Overall reliability of Muni	x	x	x
Waiting time reliability at the start of your Muni trips	x	x	x
Travel time reliability when you are on board	x	x	x
Reliability of Muni-to-Muni transfer times	x	x	x
Travel times on board Muni when there are no delays	x	x	x
How frequently Muni runs when there are no delays	x	x	x
Crowding levels	x	x	x
Comfort	x	x	x
Cleanliness of vehicles	x	x	x
Personal safety	x	x	x
Pleasantness of fellow passengers	x	x	x
Friendliness of Muni staff		x	x
Competence of Muni staff		x	x
Accuracy of real-time information	x	x	x

3.2 The Follow-up Survey

Approximately one year after the SFTQS, in February 2015, a follow-up survey was distributed to the original study participants. The follow-up survey was composed of three parts. The first part had the following questions:

1. Compared to the time during the study (October-December 2013), how much do you use Muni now?

2. On average, how often do you use Muni now?

Responses to question 1 were on a 6-point Likert scale, from stopped using Muni to use Muni much more. Responses to question 2 were on an 8-point Likert scale, from "Never" to "6-7 days/week". Participants who

stated in question 1 that their use of Muni had changed with respect to the time during the study were then presented with a third question. In the third question, a list of 20 factors was given, and respondents were asked how much influence each factor had on the travel behavior change. Possible Responses were again on a Likert scale, with of five options from "Not Influential" to "Very Influential". The fourth and fifth, which were presented to all respondents, asked about satisfaction. In question 4, respondents were asked:

4. Overall, how satisfied are you with Muni?

   Responses were on a 5-point Likert scale from "Very Dissatisfied" to "Very Satisfied".

Question 5 included a list of 15 aspects of Muni service and the following question prompt:

5. Overall, how satisfied are you with the following aspects of Muni services?

Responses to questions 4 and 5 were on 5-point Likert scales from "Very Dissatisfied" to "Very Satisfied". Question 5 was included the list of 15 aspects as shown in Table 1, in the column "Follow-Up".

4 Evaluation of Satisfaction Differences among Behavior Groups

4.1 Introduction

Given the data available from both the original study and the follow-up survey, the first objective was to evaluate whether groups of transit riders that showed different behavior in the follow-up survey gave different satisfaction ratings regarding each of the 15 aspects of service quality as well as overall satisfaction, as peoples prediction of future behavior may not always be true and we may not always have a measurement of future behavior. The follow-up survey provides the opportunity to test whether different satisfaction ratings were linked with different behavior. Therefore, the results can be used to help identify transit service satisfaction questions that are efficient in segmenting travelers into different behavioral groups. Based on the follow-up survey, the participants of the study were separated into three behavioral groups based on their observed travel behavior a year after the study, as revealed in the follow-up survey. The first group included participants who were using transit less than during the original study (The "Less" group), and the second and third group included participants who were using transit the same or more, respectively (the "Same" and "More" groups). However, the size of the "More" group is limited, as only 23 participants reported using Muni more than during the study. The "More" group is therefore not included in the analysis. The distributions of satisfaction ratings regarding 15 aspects of transit service quality were compared with

each other for each of the groups.

4.2 Methodology

The statistical model used here is intended to test whether, for each aspect of transit service quality, each participants satisfaction response is independent of the persons observed future behavior. Since the responses to all questions regarding satisfaction with aspects of Muni service are on an ordinal measurement scale, we have two categorical variables (satisfaction and behavioral group) from a single population. The Chi-square test is a statistical method commonly used for assessing whether there is a significant association between categorical variables. The test can indicate whether the "Less" group is significantly different from the "Same" group. In total, this series of tests is conducted three times, using three different data sets. The first two data sets include the results from two different surveys: the exit survey, and the follow-up survey. A further data set contains the difference between satisfaction ratings in the exit and the follow-up survey.

4.3 Results

Participants who failed to provide responses for each aspect of satisfaction are excluded from the following analysis in an effort to keep the sample size constant. Participants who indicated in the follow-up survey that they had moved out of San Francisco were also excluded, since it is assumed that there may be other, unobserved factors driving their responses. This results in the following sample sizes: 146 respondents who had decreased their Muni use ("Less" group) and 111 whose Muni use had remained the

same ("Same" group). The results are shown in Table 2. All 15 aspects of services are listed in the rows while the columns present the results for the three different data sets. Each cell value represents the p-value from a model tested using the Chi-Square Test. As an example, the top-left cell contains the result of a model comparing satisfaction with overall reliability for the two different groups, based on the data in the exit survey. Based on these results, the aspects of Muni service where there is a significant association between satisfaction responses and the behavioral group in the exit survey are "the ability of Muni to meet one's travel needs", travel time on board when there are no delays, service frequencies of Muni and safety.

Meanwhile, in the follow-up survey, more tests suggested the rejection of the independence hypothesis. For tests on waiting time reliability, travel time reliability, travel time on board when there are no delays, and the ability of Muni to meet one's travel needs, significant differences in the frequency distribution of satisfaction ratings are identified between the "Less" and the "Same" group. We conclude that for most reliability-focused question in the follow-up survey, the two groups are not on the same satisfaction level. Only satisfaction with the reliability of Muni-to-Muni transfers showed no significant differences between the behavioral groups in both the exit survey and the follow-up survey. Nonetheless, the results indicate that satisfaction with reliability is possibly a good variable to help predict actual behavior. Interestingly, most questions regarding the travel environment, from crowding levels to the pleasantness of fellow passengers, show no noteworthy association between the behavioral group and the satisfaction ratings. This is the case in both the exit survey and the follow-up survey. Furthermore,

responses to the question "How satisfied are you with Munis ability to meet most of your travel needs?" appear to differ significantly between the two behavior groups in both surveys. However, this is a higher-level question, and different participants are likely to have different views of how Muni can meet their travel needs.

Satisfaction with the reliability of waiting time showed an independence between the behavioral group and satisfaction ratings in the exit survey, but a significant association in the follow-up survey. This suggests that at least one of the behavioral groups saw a change in their satisfaction responses during the period between the exit survey and the follow-up survey. The results from tests on the third dataset confirmed this finding. For the satisfaction with the reliability of waiting times, the result suggests that one behavioral group either decreased or increased its satisfaction ratings more significantly than the other group during the time period between the exit survey and the follow-up survey.

This conclusion is further validated by an evaluation of the means, where it is seen that on average, the "less" group provided a lower satisfaction rating for each satisfaction variable as compared to the "same" group. Overall, these results suggest that various aspects of satisfaction have the potential to predict users actual future behavior. Across all the aspects of Muni service that were included in these survey questions, low satisfaction ratings in regard to service reliability are potentially a precursor to a decrease in transit use.

Table 2: Chi-Square Tests

	Exit	Follow-Up	Follow-Exit
Overall Reliability	0.311	0.615	0.478
Ability to use Muni to meet most of your travel needs	0.015	0.001	0.672
Waiting time reliability at the start of your Muni trips	0.115	0.036	0.079
Travel time reliability when you are on board	0.318	0.036	0.330
Reliability of Muni-to-Muni transfer times	0.682	0.307	0.068
Travel times on board Muni when there are no delays	0.059	0.012	0.117
How frequently Muni runs when there are no delays	0.001	0.125	0.471
Crowding levels	0.832	0.920	0.905
Comfort	0.134	0.490	0.819
Cleanliness of vehicles	0.360	0.403	0.369
Personal safety	0.044	0.123	0.705
Pleasantness of fellow passengers	0.710	0.882	0.145
Friendliness of Muni staff	0.294	0.257	0.208
Competence of Muni staff	0.244	0.006	0.543
Accuracy of real-time information	0.578	0.461	0.252
overall satisfaction	0.795	0.218	0.872

5 Evaluation of Aspects of Satisfaction

5.1 Introduction

As was discussed in section 2, the satisfaction of transit passengers furnishes a subjective assessment of the quality of service provided. The measurement of satisfaction has a long history in transportation market research and has been discussed broadly in the psychology and market research literature. A better understanding of how the transit service is fulfilling the needs of customers is believed to provide valuable information on what improvements to service quality are necessary for a transit agency. In the customer satisfaction surveys that were conducted for the San Francisco Travel Quality Study, 13 different satisfaction-related questions were asked, covering various aspects of service quality. The objective of this section of the thesis is to evaluate divergences between the 13 aspects of satisfaction and to deter-

mine whether these aspects can be summarized in groups, such that service quality can be assessed using a smaller number of underlying factors.

5.2 Methodology

Two multivariate analysis techniques are used in this analysis. First, an exploratory factor analysis (EFA) using Maximum Likelihood estimation and a VARIMAX rotation, as proposed by Kaiser (1958), will be conducted to link the observable satisfaction variables to a set of unobservable latent factors, which are thought to describe the underlying structure of Customer Satisfaction. In the case of this study, a latent factor is retained only if it provides a sum of squared loadings (SS) greater than 1. The results of the EFA will determine whether a factor analysis model is efficient and valuable in describing structural relationships between variables. Building on that, A Structural Equation Model is performed to explain the correlations or covariances in terms of the relationships of Each aspect of Satisfaction and overall satisfaction. The Lavaan package in R was used to conduct this analysis.

5.3 Exploratory Factor Analysis

In the first exploratory factor analysis, a list of 11 observed satisfaction variables is included. This is the same list as in Table 1 but excluding Ability of Muni to meet most of my travel needs and the reliability of Muni-to-Muni transfer times. As mentioned in previous section, the former is a higher-level measure which is thought to be an aggregation of other measures of satisfaction. The latter is removed because it specifically measures a participants

satisfaction with transfer reliability, but the ability of the respondent to indicate such a satisfaction depends on how much experience the respondent has with Muni-to-Muni transfers. Thus, it depends on the unique travel schedule of each participant.

The results from the exploratory factor analysis are shown in Table 3. To select the model best representing the variance of the observed variables, 3 criteria were used: (1) factor loadings had to be larger than .5 to be representative variables of a factor; (2) the representativeness of a variable is reflected as a high loading only in one factor; and (3) the variables selected should be interpretable and easily understood [Fielding et al., 1985]. Based on these criteria, two variables are not included in the table as they either did not have any significant loadings, or they loaded highly on two factors, frequency of Muni with no delay and crowding level. As can be seen in Table 3, the different aspects of satisfaction with Muni loaded well onto four factors. Upon closer inspection, it can be seen that these factors measure the underlying satisfaction with Reliability, the travel environment, comfort and scheduling aspects of Muni service. These results appear to be intuitive. The significance of the four factors implies that a single satisfaction question of measuring, for instance, overall satisfaction with Muni services, does not fully capture the dimensions of how users feel about the service.

5.4 Structural Equation Model

A further exploratory factor analysis was conducted during the study, the results of which are not shown here in table form. Unlike the previous factor analysis, this one included overall satisfaction as one of the variables. The

Table 3: Exploratory Factor Analysis of Satisfaction

Factors/Variables	Factor Loading	SS loading	Variance Explained (%)
Satisfaction of Reliability		2.499	20.8
Overall Satisfaction	0.720		
Overall Reliability	0.848		
Waiting time reliability at the start of your Muni	0.713		
Travel time reliability when you are on board	0.541		
Satisfaction of Environment		1.830	15.2
Cleanliness of vehicles	0.575		
Personal safety	0.755		
Pleasantness of fellow passengers	0.693		
Satisfaction of Comfort		1.359	11.3
Comfort	0.900		
Satisfaction of Schedule		1.345	11.2
Travel times on board Muni when there are no delays	0.974		
Total variance explained = 58.6%			

purpose of this factor analysis was to determine critical aspect of satisfaction that affect the overall satisfaction. Surprisingly, the result showed that overall satisfaction loaded most strongly on the reliability factor. To test and verify this finding, a simple structural equation model was created to determine the relationship between each aspect of satisfaction and overall satisfaction with Muni services. In the process of developing models, we are also limited by our relatively small sample size. Due to the limited sample size, it was important to control the number of parameters and the complexity of the larger structural equation model which will be presented in section 6. Therefore, the structural equation model of overall satisfaction, presented in this section, was estimated separately.

In the structural equation model presented in this section, four hypothesizes were tested:

- H_{13}: Satisfaction with Transit Reliability has a positive effect on overall satisfaction
- H_{14}: Satisfaction with the travel environment has a positive effect on

overall satisfaction

- H_{15}: Satisfaction with comfort has a positive effect on overall satisfaction

- H_{16}: Satisfaction with transit schedules has a positive effect on overall satisfaction

The structure of the measurement model was based on the exploratory factor analysis discussed in section 5.3. Satisfaction data from Exit Survey is used, which provide us a sample size of 363. Six important and widely-used goodness-of-fit indexes are described: The Chi-squared statistic over the degrees of freedom ($X^2/d.f.$), the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), the Goodness-of-fit Index (GFI), the Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI). Common rules of thumb for the CFI, GFI, NFI and NNFI suggest that values greater than or equal to 0.9 indicate a good fit. Likewise, a value of less than or equal to 5 for ($X^2/d.f.$) and less than or equal to 0.08 for RMSEA are considered indicators of a good fit [Washington et al., 2010]. For the analysis conducted in this study, ($X^2/d.f. = 2.474$), which is significantly better than the general threshold for model acceptability. The same is the case for all the remaining fit indexes, with and RMSEA of 0.075, a CFI of 0.956, a GFI of 0.944, an NFI of 0.929 and an NNFI of 0.930. Hence, we conclude that the measurement model has a good fit.

Based on the measurement model described above, the structural model used to test the four hypothesizes is depicted in Figure 1. Latent variables are shown as ellipses while observed variables are shown as rectangles. A

causal relationship or effect is denoted by a solid arrow. As shown in Figure 1, only one of the structural paths depicted is estimated to be significant, namely the effect of satisfaction with transit reliability on overall satisfaction, which is positive and significant. That is, the higher transit passengers satisfaction with transit reliability, they more satisfied they tend to be with transit overall. On the other hand, the coefficients and p-values for the other three factors are insignificant, indicating that satisfaction with the travel environment, with comfort, and transit schedules have minor effects on overall satisfaction with transit services. Nonetheless, two out of those three relationships are estimated to be positive, which matches intuitive expectations. The third relationship, between satisfaction with transit schedules and overall satisfaction with the service, is estimated to be negative, albeit, again, not significant. These results gives some indications for transit operators that an increases in transit service reliability are more likely to improve the overall satisfaction of passengers than improvements to other aspects of the service.

Since many routes in San Francisco have relatively high service frequencies, it is also possible that the data set did not contain enough variability on the dimension of service frequencies to adequately capture the relationship between that variable and overall satisfaction.

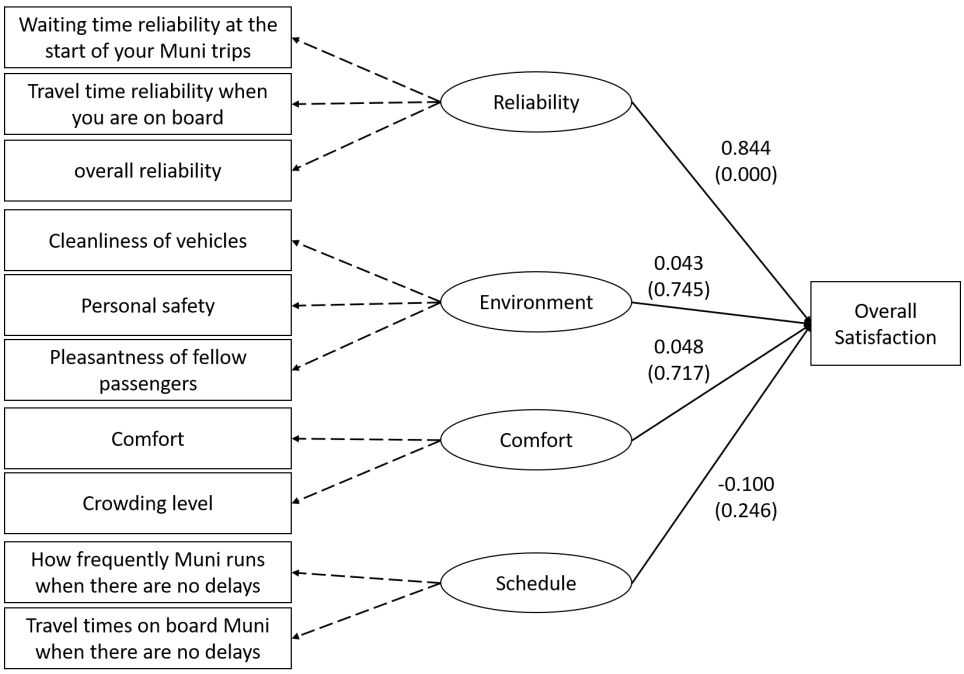

Figure 1: Satisfaction model framework ($p-$value in parentheses)

6 Factors predicting actual behavior

6.1 Introduction

In this section, the impact of transit riders negative experiences on overall satisfaction as well as the effect of overall satisfaction on attitudes, behavioral intention, and observed future behavior are examined. Negative experiences include a long wait at the origin stop, a delay while on board, and a lack of available seats due to crowding. Overall satisfaction with transit services is expected to positively influence attitudes toward public transportation, intentions, and in particular, whether a person would remain a transit rider in the future (observed behavior). Observed behavior is measured by the average frequency of Muni use reported during the follow-up survey, which in turn is modeled as a function of behavioral intention, attitudes toward using automobiles in San Francisco, attitudes toward the transit accessibility of a new residence, and overall satisfaction with Muni services. In the Theory of Planned Behavior (TPB), Ajzen [1991] demonstrated that behavioral intentions explained a great deal of observed behavior. In our modeling framework, a larger value of observed behavior indicates a higher frequency of Muni use reported in the follow-up survey. According to the TPB, attitudes toward a behavior (in this study, Muni use), subjective norms, and behavioral control together are predictors of behavioral intentions. In this data set, no variables directly measuring attitudes toward public transportation were available, so attitudes toward the transit accessibility of a hypothetical new residential location and attitudes toward using automobiles in San Francisco are used instead. Ideally, subjective

norms and behavioral control should be included as well, but the original data set did not include measurements of those constructs. Therefore, in our model, behavioral intention is influenced by overall satisfaction with Muni services, attitudes toward transit accessibility of residential locations, and attitudes toward using automobiles in San Francisco. We used two measurements of behavioral intention, short-term intended behavior and long-term intended behavior, from the exit survey to generate a behavioral intention factor. While the original measurements of behavioral intention were on a relative scale (i.e., in the future, do you intend to use Muni more, less, or the same as now?), the new measure is on the same scale of use frequencies as the observed behavior variable. This was done by comparing the relative indicators to reported frequency of Muni use before and during the study. Two indicators are used to measure attitudes toward transit accessibility of a residential location, while three indicators are used for attitudes toward using automobiles in San Francisco. Intuitively, we would expect a positive attitude toward car use to indicate a lower need for a transit accessible residence, and to correspond to lower future transit use. A total of 11 hypotheses were tested, as depicted in the structural model in Figure 2. Error terms of each variable are not shown. The hypotheses were as follows:

- H_1: Negative experiences have a negative effect on overall satisfaction
- H_2: Negative experiences have a positive effect on attitudes toward car use.
- H_3: Satisfaction with transit services has a positive effect on attitudes toward transit accessibility.
- H_4: Satisfaction with transit services has a positive effect on behavioral intentions (to continue using transit in the future)

- H_5: Satisfaction with transit services has a positive effect on observed future transit use, independently of behavioral intention
- H_6: Attitude toward car use has a negative effect on observed future transit use
- H_7: Attitude toward car use has a negative effect on attitude toward transit accessibility of the residential location
- H_8: Attitude toward car use has a negative effect on behavioral intentions
- H_9: Attitude toward transit accessibility of the residential location has a positive effect on behavioral intentions
- H_{10}: Attitude toward transit accessibility of the residential location has a positive effect on observed future transit use
- H_{11}: Behavioral intentions have a positive effect on observed future transit use

6.2 Results

A sample size of 264 respondents is obtained from the data. For the estimation of the structural equation model, a maximum likelihood method is again chosen because the data are approximately normal distributed. The goodness of fit of the measurement model is examined using the same goodness-of-fit measures presented in the previous section, where all five measures need to meet the standard rules-of-thumb to indicate a good model fit. ($X^2/d.f. = 1.327$) is below the required threshold value of 5. The RMSEA (0.035) satisfies the goal of a value less than 0.08. All the remaining measures are above the minimum threshold of 0.9, with a CFI of 0.98, a GFI of 0.96, a NFI of 0.925 and a NNFI of 0.971. As the fit was satisfactory, no further modification was made to the model framework.

Using the measurement model, all hypothesis paths were tested. The results are shown in Table 5. As expected, negative experience with transit have a significant negative effect on passengers satisfaction with transit service (standardized coefficient= -0.778, p-value=0.000) and a significant positive effect on attitudes towards car use (standardized coefficient=0.25, p-value=0.008). That is, as a transit passenger experienced more negative transit services, she tends to develop a more positive attitude toward car use [Friman et al., 2001]. At the same time, a positive attitude toward car use is found to have a negative effect on attitudes toward transit accessibility. In other words, transit users who think more positively about using a car in San Francisco tend to consider it less important to live in a neighborhood with good public transit accessibility. However, the attitudes towards car use do not appear to directly affect frequency of public transit use, as the coefficients of the directional paths from attitudes toward car use to intentions and observed behavior are very insignificant (H_6, H_8). We further hypothesized that overall satisfaction with transit use has positive effects on attitudes toward transit accessibility of residential locations, behavioral intentions, and future transit use. The results for all three directional paths were not statistically significant. The relation between satisfaction and intention or future behavior remains unclear and it appears that satisfaction alone might not be sufficient enough to determine the future intentions, let aside actual behavior. Lastly, the coefficient of the effect of intention on observed behavior is positive and close to 1 (p-value$<$ 0.001), suggesting that transit use intentions are strongly correlated with observed behavior a year after the study. This result is in line with the assumptions of the

Table 4: Estimated Results for the prediction structural model

Model component and variable	Estimate	Standard Error	p Value
Structural model of Satisfaction			
Negative Experience with Muni	-0.788	0.150	0.000
Structural model of Attitude toward Vehicles			
Negative Experience with Muni	0.250	0.094	0.008
Structural Model of Attitude toward Transit Accessibility			
Satisfaction	-0.075	0.077	0.333
Attitude toward Vehicles	-0.363	0.119	0.002
Structural Model of Behavior Intention			
Satisfaction	0.002	0.060	0.968
Attitude toward Transit Accessibility	0.452	0.122	0.000
Attitude toward Vehicles	0.126	0.100	0.208
Structural Model of Observed Behavior			
Satisfaction	0.093	0.087	0.286
Behavioral Intention	0.964	0.144	0.000
Attitude toward Transit Accessibility	0.387	0.184	0.036
Attitude toward Vehicles	0.097	0.143	0.499

TPB. Summarizing everything stated above, Hypothesis 3, 4, 5, 6, 8 lacks statistical support based on our data, while the rest paths have the expected associations.

7 Discussion and Conclusions

This article investigates travelers satisfaction and decision making by designing three comprehensive statistical analysis. The first analysis addressed the association between changes in travel behavior and shifts in satisfaction over time. The second analysis studied whether the large number of satisfaction measures can be reduced to smaller dimensions without losing too much information. The last comprehensive model further evaluated whether the selected satisfaction features are good predictors of travel behavior changes. This study based on the survey data from a large-scale San Francisco Muni transit study, which was collected at several moments: before participants joined the study, right after the study ended and a year later.

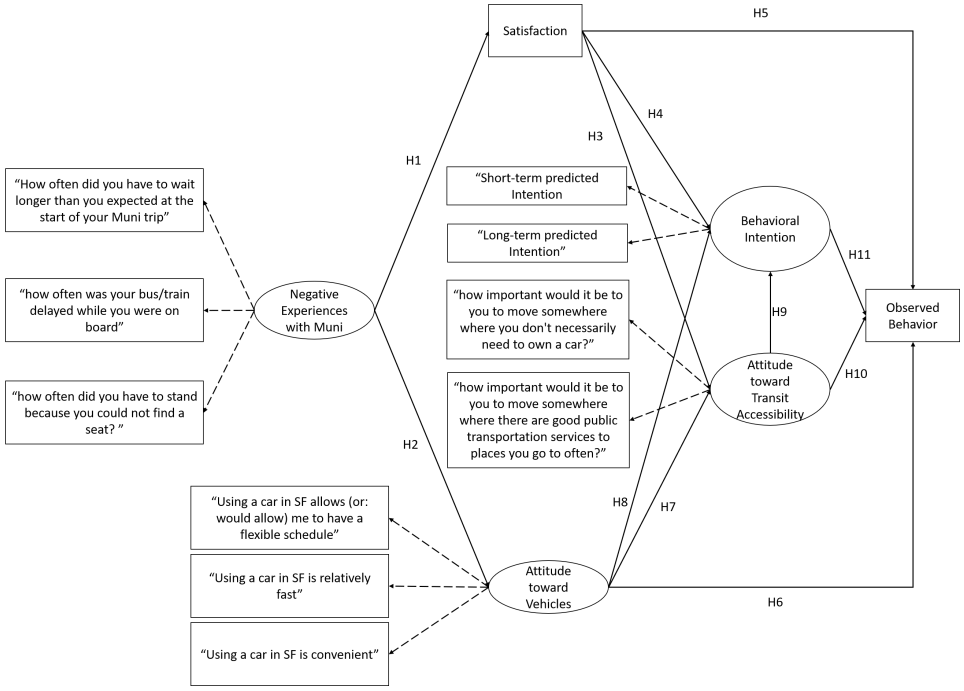

Figure 2: The structural model ($p-$value in parentheses)

The distribution of 16 measures of satisfaction were tested conditioned on three observed future behavior group: Less, Same and More. The last group is excluded from further analysis due to the limitation of sample size. The results may provide several useful advices for public transit agencies. Overtime, customer satisfaction is dynamic and reflects the same direction as the shifts in usage frequency. Hence, a sequence of surveys in a short-time period is likely to be more powerful that a one-time survey. The significant divergence in transit reliability measures suggests that to reduce the transit usage decline, a more reliable frequency and travel time schedule is more efficient.

Using the structural equation model, the analysis showed how 11 measures of satisfaction can be reduced to 4 major aspects of service: Reliability, Environment, Comfort and Schedule. More importantly, when participants are asked to rate their overall satisfaction, service reliability aspect plays a major impact in the rating. Another key point of this study is to evaluate the theory of planned behavior when actual future behavioral change is observed with the behavioral intention, overall satisfaction and attitudes included. Our results confirmed that behavior intention has a significant positive effect on actual behavior changes performed, while the link between satisfaction with transit service and the forging of intention is not obvious.

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